REMARKS

Claims 3 and 4 are pending in the application. Claims 1 and 2 were rejected under 35 U.S.C. § 112, second paragraph, as described on page 2 of the Office Action. Claims 1 and 2 were rejected under 35 U.S.C. § 103 as described on page 3 of the Office Action. Claim 3 is the only independent claim.

Attached hereto is a Substitute Specification that includes amendments to place the application in correct idiomatic English. It is respectfully submitted that the substitute specification contains no new matter. Additionally attached hereto is a marked-up version of the changes made to the specification by the current amendment. The attachment is captioned "**Version with Markings to Show Changes Made**."

It is respectfully submitted that the outstanding rejections of claims 1 and 2 are moot, as the claims have been cancelled.

It is respectfully submitted that claims 3 and 4 comply with 35 U.S.C. § 112, second paragraph.

It is respectfully submitted that claims 3 and 4 are patentable over Fang within the meaning of 35 U.S.C. § 103 for the following reasons.

Page 3 of the Office Action indicates that Fang does not disclose heating the material in a heating temperature of 1150 - 1250°C. However, the Office Action nevertheless indicates that heating the material in a temperature of 1150 - 1250°C would not be a patentable distinction and furthermore that the Applicant has not demonstrated that the claimed forging temperature is somehow critical and productive of new and unexpected results.

It is respectfully submitted that the Examiner has failed to establish a *prima facie* case of obviousness within the meaning of 35 U.S.C. § 103. Furthermore, it is therefore respectfully submitted that the Applicants have no duty to demonstrate criticality to rebut a *prima facie* case of obviousness.

35 U.S.C. § 103 authorizes the Patent and Trademark Office to refuse granting of a patent:

> if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a

> person having ordinary skill in the art to which said subject matter pertains.

The underlined portion of the statute, coupled with the language in 35 U.S.C. § 102 that "a person shall be entitled to a patent unless" (emphasis added) places a heavy burden on any Examiner seeking to reject the claims of a patent application for obviousness, for it is the task of the patent Examiner to produce the factual basis for a rejection under 35 U.S.C. § 103. *In re Warner*, 379 F. 2d 1011, 154 USPQ 173 (CCPA 1967).

To safeguard the rights of patent Applicants and prevent perfunctory dismissal of patent claims, Congress and the Patent and Trademark Office have enacted statutes or rules and procedures which must be followed in the examination process.

35 U.S.C. § 132 mandates the Patent and Trademark Office, whenever rejecting any claim for a patent to:

> notify the applicant thereof, stating the reasons for such rejection ... together with such information and references as may be useful in judging of the propriety of continuing the prosecution of his application.

Section 706.02(j) of the Manual of Patent Examining Procedure Instructs:

> [a]fter indicating that the rejection is under 35 U.S.C. § 103, the examiner should set forth in the Office Action (A) the relevant teachings of the prior art relied upon, preferably with reference to the relevant column or page number(s) and line number(s) where appropriate, (B) the difference or differences in the claim over the applied reference(s), (C) the proposed modification of the applied reference(s) necessary to arrive at the claimed subject matter, and (D) an explanation why one of skill in the art at the time the invention was made would have been motivated to make the proposed modification.

As a matter of Patent and Trademark Office practice, then, due process under 35 U.S.C. § 132 requires an Examiner, whenever rejecting a claim under 35 U.S.C. § 103, to include in his official action, (1) a statement regarding the features of the invention set forth in Applicants' claims; (2) a comparison of the claimed features of the invention with the closest prior art reference or references; (3) an explanation of why the differences between the features of an Applicants' claimed invention and the closest counterparts in the prior art are such that the claimed invention as a whole would have

been obvious to one of ordinary skill in the art at the time the invention was made, and (4) substantiation of that explanation with either evidence in the form of prior art references or sound scientific reasoning such that one may take official notice of it. See, for example, *In re Hughes*, 345 F.2d 184, 145 USPQ 467 (CCPA 1965); *In re Soli*, 317 F.2d 941, 137 USPQ 797 (CCPA 1963). Indeed, whenever a claim is rejected under 35 U.S.C. § 103, the Examiner must "expressly make the three factual determinations required by Graham and consider objective evidence of obviousness before the legal conclusion of obviousness vel non is made." *Hybritech Inc. v. Monoclonal Antibodies, Inc.* 802 F2d 1367, 231 USPQ 91, 93 (Fed Cir. 1986)

In the present case, the rejection is under 35 U.S.C. § 103 and the reference shows or describes an invention other than the claimed invention. On the record there are differences between the prior art teachings and what is claimed. Specifically, Fang does not teach heating a material to a temperature in the range of 1150 - 1250°C. The Examiner asserts that the "prior art forged product finishing temperature is 850 - 1250C (see line 65-67, column 4)." From this teaching, the Examiner extrapolates that "the starting temperature for forging can be higher than 1050C." While not admitting the accuracy of this nebulous assertion, it is respectfully submitted that the Examiner has failed to establish a *prima facie* case of obviousness within the meaning of 35 U.S.C. § 103. In particular, the Examiner has failed to provide evidence, in the form of prior art references or sound scientific reasoning, of heating the material in a temperature range of 1150 - 1250°C as required in independent claim 3.

Accordingly, it is respectfully submitted that the Applicants have no duty to demonstrate that heating the material to a temperature in a range of 1150 - 1250°C is "somehow critical and productive of new and unexpected results." In particular, a showing of criticality may be used to rebut a *prima facie* case of obviousness. However, in the present case as indicated above, the Examiner has failed to establish a *prima facie* case of obviousness.

For the reasons discussed above, it is respectfully submitted that claim 3 is patentable over the prior art of record within the meaning of 35 U.S.C. § 103. Furthermore, as claim 4 is dependent upon claim 3 and therefore includes all the limitations thereof, it is respectfully submitted that claim 4 additionally is patentable over the prior art of record within the meaning of 35 U.S.C. § 103.

Having fully and completely responded to the Office Action, Applicants submit that all of the claims are now in condition for allowance, an indication of which is respectfully solicited.

If there are any outstanding issues that might be resolved by an interview or an Examiner's amendment, the Examiner is requested to call Applicants' attorney at the telephone number shown below.

Respectfully submitted,

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Version with Markings to Show Changes Made

#4

TITLE OF THE INVENTION

Forging method

BACKGROUND OF THE INVENTION

The present invention relates to a forging method, more specifically a forging method ~~realized in a way to improve~~ that improves workability in machining, by turning the metallographical structure of products subject to impact load to a fine ferrite-perlite structure, without adopting the method of quenching and tempering, to obtain as strength a yield point (YP value) exceeding that by the method of quenching and tempering, and making the tensile strength (TS) smaller than that obtained by the method of quenching and tempering.

Conventionally, products subject to impact load such as connecting rod, steering knuckle, crankshaft, etc., for example, used to be manufactured by forging.

Further ~~And~~, for the manufacturing of a connecting rod, which is momentarily subject to a large impact load, the method of quenching and tempering was also used in combination with forging, to increase its strength.

However, this method of quenching and tempering not only requires a high manufacturing cost but also is unfit for products mass-produced at low cost like automobile parts, for example, today when reduction of manufacturing cost is strongly called for. ~~and,~~ For that reason, a non-refining method capable of reducing manufacturing cost is coming to be adopted in place of the method of quenching and tempering.

This non-refining method consists of ~~in~~ forcibly air cooling, after forging, high-temperature products from ~~at~~ around 1200℃ immediately, to around 500℃.

By the way, with the non-refining method by which high-temperature products at around 1200℃ are forcibly air cooled, after forging, immediately to around 500℃, the yield point (YP value) drops although the tensile strength (TS) remains at about the same level as with the method of quenching and tempering, and its value expressed by dividing the yield point by the tensile strength, i.e. value expressed in yield ratio (YR) is approximately 0.6. For that reason, this drop of yield point (YP value) as compared with the method of quenching and tempering puts an obstacle to reduction of weight of forged projects, while on the other hand a high tensile strength (TS) still remaining at about the same level as in the method of quenching and tempering means poor workability in machining in the same way as products manufactured by the method of quenching and tempering, and such were problems with the non-refining method.

SUMMARY OF THE INVENTION

In view of ~~said~~ The problems with conventional forging methods, the objective of the present invention is to provide a forging method realized in ~~such a way~~ that ~~it~~ improves workability in machining by turning the metallographical structure of products subject to impact load into a fine ferrite-perlite structure, without adopting the quenching and tempering method, to obtain, as strength, a yield point (YP value) exceeding that obtained by the quenching and tempering method, and reducing the tensile strength (TS) compared to the quenching and tempering method.

To achieve said objective, the forging method according to the present invention is characterized in that a forged material manufactured by adding at least one kind of group ~~5~~ metals (or group VB metals), To a material To be forged, heating ~~heated~~ to a temperature suitable for hot forging, ~~and after being forged~~ forging to

a prescribed shape, ~~cooled~~ cooling, ~~and then~~ ~~held~~ holding for a prescribed set time in a furnace at a tempering temperature, and ~~is~~ then further ~~cooled~~ cooling to normal temperature by natural cooling.

~~Here~~ In accordance with the present invention, it is desirable to set the "tempering temperature" at a temperature in the range of 500 ~ 700℃ and the "prescribed set time" for 30 ~ 60 minutes.

In this forging method, a forged material manufactured by adding at least one kind of group 5 metal~~s~~ to metal material consisting of perlite, ferrite, etc. (which are usually used as forged materials), is heated to a temperature suitable for hot forging, ~~and after forging~~ is forged to a prescribed shape, is cooled ~~cooling~~, ~~and~~ is then ~~being~~ held for a prescribed set time in a furnace at a tempering temperature, and is then further cooled to normal temperature by natural cooling. ~~For that reason~~ Accordingly, group 5 metals such as vanadium, niobium, etc. that were added to the forged material can precipitate, on ferrite, as fine carbon and nitride (that include mainly ~~comprised of~~ the added elements), and thereby enable the setting of a high yield point (YP value) with high rigidity and strong resistance to impact load because of the fine metallographical structure of fine ferrite + perlite. ~~making~~ The present invention therefore makes it possible to reduce the weight of forged products, control a low tensile strength (TS), and thanks to the fine metallographical structure of fine ferrite + perlite, improve workability in machining, thus promoting the reduction of manufacturing costs for forged products.

~~In this case~~ In accordance with the present invention, the heating temperature of the forged material shall preferably be set in the range of 1150 ~ 1250℃.

This promotes melting into a solid solution of group 5 metals such as vanadium, niobium, etc. that were added to the forged material~~, and~~. When they ~~are~~ have cooled and precipitated, the texture of the forged material is strained with the precipitate, and precipitates as a large volume of fine carbon nitride, while the strength of the forged

material increases because the metallographical structure becomes fine.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanatory drawing of ~~the~~ an exemplary embodiment of a forging process ~~showing the form of an embodiment of the forging method~~ according to the present invention.

Fig. 2 is an explanatory drawing of temperature changes in the same forging process ~~as above~~ of Fig. 1.

Fig. 3 is a graph showing the relations of hardness and yield rate between an embodiment of the present invention and conventional products (conventional non-refining method and conventional method of quenching and tempering).

Figs. 4(A)-4(C) ~~Fig. 4~~ show~~s~~ microscopic pictures of metallographical texture, wherein Fig. 4 (A) is ~~being~~ a microscopic picture of the metallographical texture of the embodiment of the present invention expanded at a magnification of 400, Fig. 4 (B) is ~~being~~ a microscopic picture of the same expanded at a magnification of 100000, and Fig. 4 (C) is ~~being~~ a microscopic picture of the metallographical texture of a conventional product (conventional non-refining method) expanded at a magnification of 400, respectively.

DETAILED DESCRIPTION OF THE INVENTION

An embodiment of the forging method according to the present invention will be explained below based on drawings.

Fig. 1 and Fig. 2 indicate processes of the forging method of the present invention.

Generally, products like automobile parts, etc. momentarily subject to impact load such as connecting rod, steering knuckle, crankshaft, etc., for example, used to be manufactured by ~~the~~

a method of forging, which is a method suitable for high strength, low cost and mass production.

The present invention improved the conventional ~~realized by improving this~~ method. ~~is a~~ In particular, in the present invention, ~~method in which~~ a forged material, manufactured by adding at least one kind of group 5 metals such as vanadium, niobium, tantalum, dubnium, etc. to metal material consisting of perlite, ferrite, etc., which are usually used as forged material, is heated to a temperature suitable for hot forging. The combined material is then forged ~~and, after forging~~ to prescribed shape, cooled, ~~and then~~ held for a prescribed set time in a furnace at a tempering temperature, and ~~is~~ further cooled to normal temperature by natural cooling.

In the exemplary embodiment ~~this case, as group 5 metals, it is~~ preferable non-limiting examples of group 5 metals include ~~to use~~ vanadium or niobium which are easy to obtain and inexpensive. ~~though not restricted to those items~~.

Further, ~~And,~~ the added volume of the group 5 metal may be very small, for example, ~~at~~ about 0.03 to 0.3 wt% as compared with ~~against~~ the forged material, ~~for example~~.

When ~~performing~~ hot forging by using this forged material, the heating temperature shall be set slightly lower than the heating temperature suitable for conventional hot forging (this heating temperature varies also depending on the type of forged material) or, for example, at about 1200 ℃ ± 50 ℃, in the case where the heating temperature suitable for conventional hot forging is around 1250℃, ~~for example~~.

By setting the heating temperature of forged material as described above, it becomes possible to promote melting into solid solution of group 5 metals such as vanadium, niobium, etc. that were added to the forged material. Further, ~~and,~~ when the group 5 metals cool ~~they are cooled~~ and precipitate, the texture of the forged material is strained with the precipitate and precipitates as a large volume of fine carbon nitride, increasing the strength of the forged material.

And, this forged material, heated to a temperature suitable for hot forging, is molded to a prescribed shape by hot forging using dies.

This hot forging process is the same as that in the conventional non-refining method and method of quenching and tempering.

After the forging, the forged product released from the die is cooled, by natural cooling, to a temperature close to the temperature at which group 5 metals, such as vanadium, niobium, etc., can easily precipitate, on the ferrite, as fine carbon and nitride that include mainly ~~composed of~~ The added elements. This cooling temperature, which is not particularly restricted, will be set for approximately 600 to 800℃.

This natural cooling may be made naturally during conveyance on the conveyor where the forged products discharged from the forging system are carried continuously to the heating furnace of the subsequent process, or made forcibly by such means as blowing air with a blower to the forged products on the conveyor, etc. These methods can be adopted selectively as required, depending on the carrying distance from forging system to heating furnace, required carrying time, etc.

In this way, forged products cooled to approximately 600 to 800℃ are supplied into the heating furnace.

It is so arranged that, in this heating furnace, the forged products can maintain a temperature, for example, in the tempering temperature area or 500 to 700℃ ~~, for example~~.

In this case, since the thermal energy of the forged products supplied into the heating furnace is set slightly higher than the temperature in the heating furnace, the set temperature is maintained in the heating furnace without hardly any heating except in the early period of operation, enabling energy-saving

treatment (of the forged products).

The holding time of this tempering temperature will be set for a time necessary for the group 5 metals such as vanadium, niobium, etc. to precipitate, on the ferrite, as fine carbon and nitride that include mainly ~~composed of~~ the added elements, ~~or~~ for 30 to 60 minutes or so, for example.

In that case, use of a heating furnace is not always necessary, if it is possible to maintain the prescribed temperature during the time necessary for precipitating, on the ferrite, as fine carbon and nitrides that include mainly the ~~composed of~~ added elements, by using an oven such as heat insulating oven, etc.

As described above, after the forged products are maintained at 500℃ to 700℃ in the heating furnace for approximately 30 to 60 minutes, to make the group 5 metals such as vanadium, niobium, etc. precipitate, on the ferrite, as fine carbon and nitrides that include mainly ~~composed of~~ the added elements, the forged products are taken out from the heating furnace, and cooled to normal temperature by natural cooling, into products.

This makes it possible to realize a fine metallographical structure close to that obtained by normalizing and set a high yield point (YP value) for high rigidity and strong resistance to impact load, and to thus sharply improve the yield ratio (YR). As a result, reduction of weight can be achieved and yet the tensile strength (TS) can be controlled low, ~~enabling to obtain~~ thereby obtaining forged products with improved workability in machining.

Table 1 and Table 2 indicate differences between the non-heat treated carbon steel for machine structure (S35C) to which are added 0.26% vanadium and 0.026% niobium of an embodiment of the forging method according to the present invention and conventional products (products by conventional non-refining

method and conventional method of quenching and tempering (carbon steel for machine structure with equivalent carbon content (S40) (Table 2 (A)) and with equivalent strength value (S55C) (Table 2 (B)))).

[Table 1]

Item	Present invention	Non-refining method
Heating temperature for forging	1220 ℃	1220 ℃ Blast cooling (to 500 ℃), and air cooling after that
Supply temperature for heating furnace after natural cooling	800 ℃	
Set temperature in heating furnace	600 ℃	
Set temperature holding time	30 minutes	

[Table 2]

Item	Present invention	Non-refining method	Method of quenching and tempering (A)	Method of quenching and tempering (B)
Tensile strength (N/mm^2)	1140	1162	782	962
Yield point (N/mm^2)	892	733	585	710
Yield ratio (YR)	0.78	0.63	0.75	0.74
Elongation	11.6	13.7	23.8	20.0
Reduction of area	19.2	19.6	63.8	54.4
Texture	Ferrite + Perlite	Ferrite + Bainite	Sorbite	Sorbite + Ferrite
Treating method	As described in the Specification	Same as left	842 ℃ Water cooling 538 ℃ Tempering	Same as left
Remarks	V 0.26% Nb 0.026% Non-heat treated steel	Same as left	S40C	S55C

For ~~said~~ the method of quenching and tempering, data were borrowed from ASME Hand Book (1954).

Fig. 3 indicates the relations of hardness and yield rate between an embodiment of the present invention and a conventional product (conventional non-refining method and conventional method of quenching and tempering).

Figs 4(A)-4(C) ~~Fig. 4~~ show~~s~~ microscopic pictures of metallographical texture.

Fig. 4 (A) is a microscopic picture of the metallographical texture of the embodiment of the present invention expanded at a magnification of 400, Fig. 4 (B) is a microscopic picture of the same expanded at a magnification of 100000, and Fig. 4 (C) is a microscopic picture of the metallographical texture of a conventional product (conventional non-refining method) expanded at a magnification of 400, respectively.

From those microscopic pictures, we can see that the metallographical texture of an embodiment of the present invention has ~~is~~ a fine texture.

Moreover, as it is apparent also from the microscopic picture expanded at a magnification of 100000 indicated in Fig. 4 (B), fine carbon nitride mainly composed of added elements is precipitated on the ferrite, showing improved strength of the forged material.

CLAIMS

1. A forging method characterized in that a forged material manufactured by adding at least one kind of group 5 metals is heated to a temperature suitable for hot forging, and after forging to a prescribed shape, is cooled and then held for a prescribed set time in a furnace at a in the tempering temperature, and is further cooled to normal temperature by natural cooling.

2. A forging method as defined in Claim 1, wherein the heating temperature of the forged material is set in the range of 1150 ~ 1250℃.

ABSTRACT

The objective of the present invention is to provide a forging method ~~realized in a way to~~ that improves workability in machining, by turning the metallographical structure of products subject to impact load to a fine ferrite-perlite structure, without adopting the method of quenching and tempering, to obtain, as strength, a yield point (YP value) exceeding that obtained by the method of quenching and tempering, and making the tensile strength (TS) smaller compared with the method of quenching and tempering.

~~It is so arranged that~~ A ~~a~~ ~~forged~~ material to be forged has ~~manufactured by adding~~ at least one kind of group 5 metal ~~X~~ added thereto and is heated to a temperature suitable for hot forging~~, and,~~ After forging to prescribed shape, ~~cooled~~ cooling, and ~~then held~~ holding for a prescribed set time in a furnace at a tempering temperature, ~~and~~ the material is further cooled to normal temperature by natural cooling.